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THE CULTURE OF WINTER WHEAT
IN THE
EASTERN UNITED STATES

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THE yield per acre of wheat may be increased materially by putting into practice some principles that are already well known to most farmers. This method of increasing wheat production should appeal especially to those who can not increase their acreages without doing injustice to other crops which they should grow.

The principles referred to may be summed up as follows:

(1) Plow early. Give the plowed land 2 months to settle before sowing, where possible.

(2) Compact the late-plowed land with roller and harrow.

(3) Don't plow after a cultivated crop. Prepare such land with disk and harrow.

(4) Make the seed bed a fit place for the seed.

(5) Sow with a drill, using sound, plump, clean seed of an adapted variety.

(6) Prevent losses from smut by treating the seed with formaldehyde.

(7) Make the soil fertile with manure, or with fertilizers applied judiciously.

(8) Reduce winterkilling by following the above suggestions.

THE CULTURE OF WINTER WHEAT IN THE EASTERN UNITED STATES.

CONTENTS.

THE HUMID WHEAT REGION.

The region under discussion in this bulletin includes the humid winter-wheat districts, comprising mainly the States east of Nebraska, Kansas, Oklahoma, and Texas, with a small eastern portion of each of those States and excepting the New England States. This region is shown by shaded lines on the accompanying map (fig. 1). The boundary of this region is somewhat arbitrary, as there is a zone on the north in which both winter and spring wheat are grown and another on the west where conditions may be either humid or semiarid. Within this area the rainfall shown by the numbered lines in figure 1 is usually sufficient for crop needs without resorting to special methods of tillage to conserve moisture, such as are practiced on the Great Plains. In that part of the area which lies west of the line of about 35 inches average rainfall, the hard red winter wheats of the Turkey or Crimean type are principally grown. East of this line the semihard and the soft red wheats

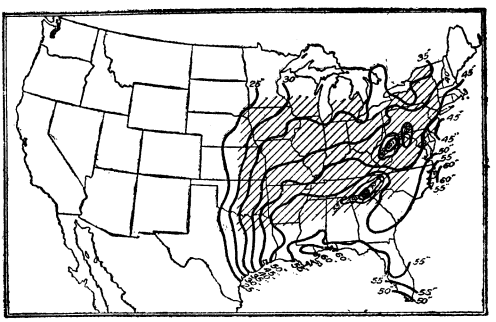


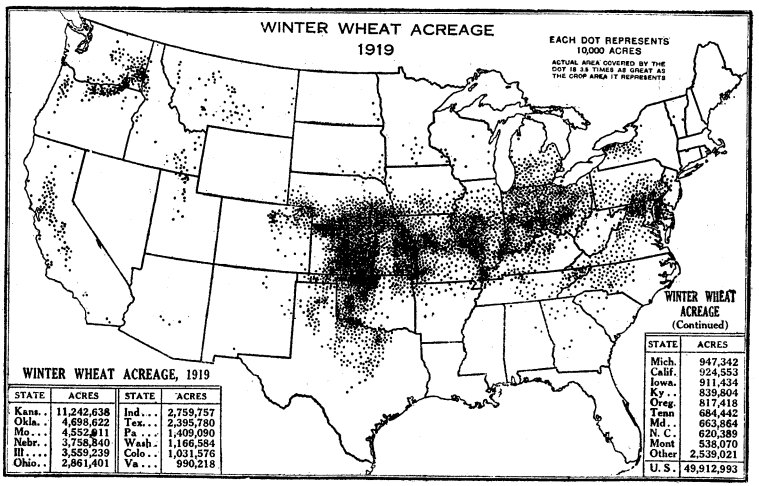
FIG. 1.—Map of the United States, showing by shaded lines that portion of the humid wheat region to which this bulletin is applicable. The boundaries are somewhat arbitrary, there being transition zones on the north and west. The average annual rainfall in inches is shown by the numbered lines.

and the soft white wheats are principally produced, the red wheats being most generally grown. (Fig. 2.)

SOILS ADAPTED TO WHEAT.

The soil best suited to the production of wheat is one which furnishes a firm yet friable seed bed, while beneath this there is a compact subsoil. It should have sufficient natural slope to allow good surface drainage and should be provided with subsoil drainage. This soil, furthermore, should contain plenty of vegetable matter and plant food and should not be acid.

These conditions are most nearly fulfilled in the loam, silt-loam, clay-loam, and some of the clay soils. Sandy soils and many heavy



STATE	ACRES	STATE	ACRES
Kans.	11,242,638	Ind.	2,759,757
Okla.	4,698,622	Tex.	2,395,780
Mo.	4,552,811	Pa.	1,409,080
Nebr.	3,758,840	Wash.	1,166,564
Ill.	3,559,239	Colo.	1,031,576
Ohio.	2,861,401	Va.	990,218

STATE	ACRES
Mich.	947,342
Calif.	924,553
Iowa.	911,434
Ky.	839,804
Oreg.	817,418
Tenn	684,442
Md.	663,864
N. C.	620,389
Mont	538,070
Other	2,539,021
U. S.	49,912,993

FIG. 2.—Map of the United States, showing the acreage of winter wheat in 1919, according to the census of 1920. Each dot represents 10,000 acres.

clay soils are not so suitable for wheat growing, the former being too loose in texture to retain moisture and the latter too compact to allow aeration and proper drainage. A silt loam overlying clay is a good combination. The Hagerstown loam of the Eastern States is one of the best for wheat growing. It is described as follows:

The Hagerstown loam is characterized through practically its entire extent by a brown or yellowish brown silty loam surface soil having a depth which ranges from 6 inches as a minimum to 12 or 14 inches in the deeper areas. This surface soil is soft and mellow and usually has the appearance of being well charged with organic matter. It grades downward into a yellow heavy loam or clay-loam subsoil, which in turn grades into a heavier clay loam or clay subsoil at a depth of 2 to 2½ feet. This deeper subsoil is not infrequently of a brown or reddish color and in practically all cases it is sharply bounded by the underlying undissolved limestone rock.

On poorly drained soils, wheat is often killed directly by the accumulation of water in low spots or is smothered by the formation of ice in winter. Wheat plants are also often heaved out of the ground by the alternate freezing and thawing in the fall and spring, this being due to the formation of ice in soils saturated with water. Sufficient moisture should be present for good growth, while all water in excess of this amount should be promptly removed by the drainage system. Winterkilling, which is usually a sign of poor drainage, is thus largely prevented. It is a frequent observation that winterkilling is worst where the humus content of the soil is least. This is probably due to the better drainage resulting from the improved physical condition of soil in which humus is plentiful.

FERTILIZERS.

There are few of the older agricultural soils suited to wheat growing on which fertilizers of proper composition will not give a profit when applied in connection with good farm practice. The object of fertilization is mainly to provide a balanced ration for the growing plant, and it is therefore necessary to supply in the fertilizer the elements of plant food which are not already available in sufficient quantity in the soil. It is likewise unnecessary to add an element already available in sufficient amount. The soil constituents which are often deficient are calcium (lime), nitrogen, potassium, phosphorus, and humus, or decaying organic matter.

Calcium is supplied as lime or limestone to correct acidity, if necessary, and also as a plant food. Nitrogen is present in manure and in nitrate fertilizers, but the principal source is from the air. It can be obtained from the air very cheaply by growing legumes, such as clover, cowpeas, and soy beans, in rotation or as catch crops. Potassium is usually present in the soil in sufficient amount and can be made available by the decay of manure and plant remains, but when absent or not readily available it is supplied as kainit, or potassium salt. Phosphorus is very generally deficient in the older wheat soils and must be supplied by the addition of some form of phosphatic fertilizer, such as acid phosphate, bone meal, rock phosphate (floats), or basic slag. Humus is supplied in stable or barnyard manure and in green manure.

Stable or barnyard manure is of great benefit when added to soils. It supplies humus by the decay of the organic matter, while nitrogen and potassium are usually contained in it in considerable amounts. It usually does not contain a sufficient percentage of phosphorus, however, to be a balanced ration for plants. If 40 or 50 pounds of acid phosphate, rock phosphate, or basic slag are added to each ton of manure as it is being made in the stable or before hauling to the field, this deficiency of phosphorus is overcome, and a better form of

fertilizer can scarcely be found. At least 8 tons per acre of this treated manure should be applied once in four years.

The Ohio Agricultural Experiment Station, after making hundreds of fertilizer tests throughout the State, has instituted on its experimental farm a method of fertilization which should be applicable to a large part of the winter-wheat region. It is described as follows:

> Corn, oats, wheat, and clover have been grown in a 4-year rotation, . . . these crops being grown on four 10-acre fields, each crop being grown every season.
>
> In this experiment, manure has been taken directly from the stable to the field. . . . This manure, moreover, has been reenforced with phosphorus carried in acid phosphate or raw phosphate rock to make up for the phosphorus taken out of their feed by the animals producing the manure, in order to build up their skeletons, the phosphate being dusted in the stables at the rate of 1 pound per 1,000-pound animal per day. This phosphated manure has been spread on the clover sod in the fall or early winter at the rate of about 10 tons per acre, and plowed under for corn, the plowed land being dressed with limestone . . . (1 ton per acre).
>
> The oats receive no treatment, but the wheat receives a complete fertilizer, made up of about 200 pounds steamed bone meal, 100 pounds acid phosphate, and 40 pounds muriate of potash in the fall, followed by 60 pounds nitrate of soda in the spring, or a total of 400 pounds per acre, having the formula 4–16–5, and costing about $6.50 per acre for the materials, or at the rate of $32.50 per ton.
>
> Allowing $5 for handling the manure, $3 for the phosphate used with it, $3 for the limestone, and $6.50 for the fertilizer, the total cost of this treatment has been $17.50 per acre for each four-year period, or $4.38 annually.
>
> The outcome of this treatment has been an eight-year average of 77 bushels of corn per acre, followed by 61 bushels of oats, 33 bushels of wheat, and 3⅔ tons of hay, thus giving an increase above the unfertilized yield of 50 bushels of corn, 31 bushels of oats, and 21 bushels of wheat, and more than three times as much hay as has been harvested from either of the hay crops on the untreated land.
>
> In other words, this 40-acre tract is yielding more than twice as much corn, wheat, and hay as the average of Ohio, and nearly twice as much oats. Of course, not all the land in Ohio is in condition to produce such yields. Much of it is deficient in drainage and there are some areas of thin, cold clay that will require not only drainage, but also such treatment as will increase the supply of vegetable matter in the soil, before any system of fertilizing can have its full effect. But the response which is being given by soils in other parts of the State to certain parts of the treatment above described is sufficient to show that the yields of the great majority of Ohio farms may be very materially increased by measures which will be abundantly reimbursed in each year's crops.

Green manures are any green crops that are grown and plowed under for soil benefit. By their decay they furnish humus and make available certain mineral elements already in the soil. Rye is very good for this purpose, though it is better not to use this crop alone, but in combination with a legume. The legumes are usually grown for green manure, however, as they furnish abundant green material to plow under and also have the added advantage of being able to

change the nitrogen of the air into a form available for the use of plants.

When barnyard or other rotted manure is not available and plant remains, such as straw and stubble, are not returned to the soil, the growing of suitable green-manure crops is imperative in order to maintain soil fertility and the supply of humus. On comparatively few farms is there sufficient rotted manure to take the place of green manures altogether, although by returning the plant remains to the soil less of the green manure will need to be grown than where no returns are made. By the proper care of plant residues and the use of green-manure crops, principally the legumes, fertility can be maintained as cheaply and as effectively as with the use of large amounts of rotted manures only.

The amount and kind of commercial fertilizers to be added in a system of farming where no stable or barnyard manure is produced would not differ from that given in preceding paragraphs as in use in Ohio. The applications of lime, phosphorus, potassium, and nitrogen should be made as there directed, except that rotted straw may take the place of the manure or the phosphate may be added directly to the clover sod and not in connection with manure. The rotation of corn, oats, wheat, and clover can be made to furnish sufficient humus to the soil. To do this, cornstalks generally should not be removed. Only the seed of the clover crop should be removed, and all straw and other plant remains should be returned to and incorporated with the soil.

ROTATIONS.

It is not advisable to crop wheat continuously on the same land, as such a practice results in depleted soil fertility, poor physical condition of the soil, increased growth of weeds, mixtures of grain varieties, and lowered yields of poorer quality. Even if soil fertility and a fairly good physical condition are maintained by the addition of chemicals, such a cropping system is not advisable, on account of its cost and the further reasons just cited.

A rotation of grain crops only is but little better than continuous wheat, as there is no nitrogen-adding crop, and humus is likely to be exhausted by this system. The fallow system is also impracticable in the region under discussion.

A good rotation system should include a legume and a cultivated crop. Local conditions should determine the rotation and the particular crops to be used. The stirring of the soil incident to cultivation has a beneficial effect upon its chemical and physical conditions and tends to eradicate weeds. Manures can also be worked in by cultivation and made available for the wheat crop. In much of the humid areas a rotation in which corn, tobacco, cowpeas, or soy beans

precede wheat is practicable. The purpose of growing a legume is to gather nitrogen from the air and store it in the soil, and also to help maintain the supply of humus. The clovers in the Northern States, and cowpeas, soy beans, vetch, and crimson clover in the Southern States, are the leading legumes for this purpose. Vetch is usually grown with rye in the East and South.

A good rotation, especially for the northern part of the winter-wheat region, is corn, oats, wheat, clover and timothy (two years). This may be modified by the omission of the oats or the timothy, or both. Cowpeas or soy beans may be substituted very profitably for oats in many localities where oats do not pay, or wheat may be grown twice in succession. In tobacco-growing localities tobacco may be so substituted; barley may also take the place of oats in some localities. It is being recognized that wheat after cowpeas or soy beans is more profitable than after corn; hence, a rotation of corn, cowpeas, or soy beans, wheat, and clover is advisable where these legumes are adapted.

On soils suitable for wheat in the South the rotation may be as follows:

(1) Cotton, with crimson clover sown at the last cultivation and plowed under the following spring.

(2) Corn, with cowpeas sown between the rows at the last cultivation.

(3) Wheat, followed by cowpeas, followed by rye. The cowpeas following the wheat crop may be cut for hay, or they may be disked in or plowed under as green manure.

WHEAT AS A NURSE CROP.

Winter wheat is one of the most satisfactory nurse crops. Winter barley is probably better in the Southern States, where it can be grown, as it matures earlier and does not grow so tall. Wheat is better than spring oats, because it does not make so much shade and is removed from the ground earlier in the season. By the early removal of the grain crop the young clover and grass plants are benefited by the moisture remaining in the soil, which is very important in dry seasons. When used as a nurse crop the stubble should be left as high as possible, to furnish some protection and support to the young grass and clover. The shocked grain should be removed from the field as soon as possible after cutting, to avoid injury to the seeding.

WHEAT AS A COVER CROP.

Where a good growth of wheat is secured in the fall, the crop is valuable in preventing the washing which is so prevalent whenever heavy clay soils are unprotected. The leaching out and loss of plant food and fertilizers by the winter rains are also largely reduced by such a cover crop.

PREPARATION OF THE SEED BED.

The principle underlying the preparation of soil for wheat is that the seed bed must be firm, moist, and well compacted beneath, with a mellow, finely divided upper 3 inches of soil. If wheat is grown in rotation with oats or after wheat, the stubble should be plowed to a depth of at least 7 inches immediately after harvesting the crop of grain. The ground should be harrowed within a few hours after plowing, and cultivation with harrow, disk, drag, or roller should be given as necessary thereafter until planting time, to kill weeds, to settle and make firm the subsoil, and to maintain a soil mulch above. Late plowing does not allow time for these results to be obtained.

Experiments at the Kansas Agricultural Experiment Station furnish evidence that "the largest yields of wheat and the largest profits result from those methods of preparation by which the soil is worked early in the season and kept cultivated until the wheat is sown and when wheat is grown in rotation with other crops. There may be an exception to very early plowing on fertile soils in wet seasons. Under these conditions medium early plowing is advisable."

If a cultivated crop precedes wheat, frequent cultivation given to this crop will preserve moisture and maintain a soil mulch. If level cultivation has been practiced, a good seed bed can usually be prepared by disking and harrowing after removing the crop. If weeds are present, however, it may be advisable to plow shallow, the disk preceding and following the plow.

Early plowing and thorough tillage of the plowed soil aid in catching the water which falls and in storing this and the water already in the soil for use by the wheat plants. The firm seed bed under this mulch enables the young wheat plants to make use of the subsoil waters which rise by capillarity when there is a perfect union between the plowed soil and the subsoil. Sufficient water is thus assured for the germination of the seed when sown and for the early fall growth of the seedlings, a very important consideration. Plant food is also likely to be more abundant in the soil when such methods are employed.

If the importance of thorough tillage were more generally recognized and proper methods of seed-bed preparation were employed more commonly throughout the so-called humid areas, there would be less frequent losses from drought and better wheat crops would result. In this area the mistake is often made of thinking that there will always be moisture enough present for maximum crop growth, with the result that short crops are often obtained where more attention to moisture preservation would have assured good yields.

PREPARATION OF THE SEED.

It is usually advisable to use home-grown wheat for seed. It has been shown by experiment that seed acclimated to a locality generally gives better yields than seed of the same variety brought from a distance. The practice of changing seed each year or every few years is not justified by experimental results. Any change that is made should be for the purpose of establishing a better variety of known value. Small tests should be made of a new variety in a locality in order to establish its value and allow for acclimatization before general sowings are made.

Broken, immature, and shriveled grains, weed seeds, and all foreign material should be removed by fanning and grading the seed before it is sown. The fanning mill will also remove smut balls and many grains affected by scab, as these are lighter than the sound grain.

Where stinking smut is present, seed wheat should be treated with copper carbonate according to the method described in Department Circular 394, entitled: "Copper Carbonate Prevents Bunt (Stinking Smut) of Wheat."

The control of the loose smut of wheat is difficult, but it can be accomplished by the hot-water treatment described in Farmers' Bulletin 939. As infection of the seed with this disease occurs at the time of flowering, it can be avoided by sowing seed from fields or portions of fields in which no smutted heads are found.

Little difficulty is usually experienced in regard to the germination of seed wheat. Should any doubt exist, due to the seed being old, shriveled, weathered, or otherwise not in good condition, a germination test should be made. To make a germination test several lots of 100 grains each should be counted out and placed between blotters or Canton flannel or in sand, where they must be kept moist and at a temperature of about 70° F. for several days, after which the number of seeds which show strong sprouts should be counted. Seed that is weak in vitality should be discarded or sown at a higher rate per acre than that commonly employed.

SOWING THE SEED.

METHOD OF SEEDING.

So many experiments have shown the superiority of drilling over broadcasting wheat that doubt should no longer exist regarding this point. More uniform stands are secured with less seed and winter resistance is greater where drills are used for seeding. The shoe drill, disk drill, and hoe drill are all about equally good for seeding

purposes, and it makes little difference on well-prepared soil which kind is used. In all soils except those that are very heavy or wet it is well to have the drill provided with press wheels, which firm the earth about the seed and insure close contact of seed and soil. The press wheel is especially valuable where the winters are severe and the seed bed rather loose. The drill rows should be from 6 to 8 inches apart.

The proper depth to plant seed wheat is about 2 or 3 inches. A greater depth than 3 inches is seldom advisable except, perhaps, in loose, dry soils. A depth of 1 to 2 inches is allowable when a good supply of moisture is present.

TIME OF SEEDING.

Wheat should be sown early enough to allow the plants to become well started before winter sets in, yet not so early as to allow them to become jointed. Where the Hessian fly is present, as it generally is in most of the sections where winter wheat is grown, seeding should be delayed as much as possible. The first frost in the fall destroys most of these insects and thus reduces to a minimum the damage which they inflict. The only effective means of combating this pest is the late sowing of wheat by all wheat growers in a community, accompanied by a systematic destruction of stubble or other breeding places of the insects. In seasons when the first frost is unusually delayed it is not safe to wait too long, as losses may be greater from failure of the young, poorly rooted plants to survive the winter than from injury by the fly.

The risks of late seeding may be largely avoided by providing a seed bed finely worked on top, but compact and well drained beneath, in which there is plenty of moisture and available plant food. Prompt germination of the seed and rapid growth of the seedlings thus assured will allow the plants to enter the winter in as good condition as those from seed sown earlier but less favorably.

The proper time for sowing wheat can not be exactly specified for all the area here being considered. In general, for each 10 miles of difference in latitude there is a difference of one day in the seeding date, this date being earlier as one goes north or later as one goes south from a given point. Similarly, seeding should be approximately one day earlier for each 100 feet of increase in elevation.

The proper date for localities in the latitude of northern Ohio is about the first week in September; for southern Ohio, the last week in September; for central Tennessee and central Oklahoma, about the middle of October; and for northern Georgia, about the first of November. For the Piedmont section of Virginia, allowance for

elevation must be made, and so in the northern part the middle of September and in the southern part the last week in September seem best. There is usually a period of several weeks in all the winter-wheat area, however, in which sowing may take place with about equal results. This period is longer as one proceeds southward.

RATE OF SEEDING.

The quantity of seed that should be sown under ordinary conditions in the humid winter-wheat areas is 6 pecks per acre. This may be varied according to the size of kernel of the variety used, the condition of the seed bed, the fertility and character of the soil, and the date of seeding. When the grains are small, the seed bed in good condition, the soil rich, warm, and well drained, and the seeding early, 5 or even 4 pecks per acre are often sufficient. Where opposite conditions exist, 7, 8, or even 10 pecks may give more profitable results. It is advisable to adhere to these rules with all varieties, regardless of any claims of exceptional tillering ability that may be made.

PASTURING AND MOWING.

It frequently happens, especially in the Southern States, that an overabundance of foliage is produced in the fall, and danger of winter injury is increased thereby. It is often advisable under these conditions to mow off the plants in the fall or to pasture moderately. As growing wheat is an excellent feed, it is more profitable to dispose of the excess growth in the late fall or early spring by pasturing. Excessive pasturing at any time, pasturing when the soil is wet, and late spring pasturing are very injurious and should be entirely avoided. The amount of lodging is probably reduced by judicious mowing or pasturing.

CULTIVATION OF THE CROP.

The wheat crop of the humid areas is generally not benefited by cultivation of any sort either in the fall or spring. On heavy soils in very dry seasons light harrowing early in the spring is sometimes profitable. The use of a corrugated roller is often advisable in the spring where the soil is badly heaved. It may also be beneficial to roll winter wheat immediately after sowing when the soil is dry and loose, but this treatment would probably be detrimental where soil-moisture conditions are normal.

HARVESTING THE CROP.

TIME OF CUTTING.

Where a self-binder is used, wheat may be cut with safety when the straw has lost nearly all of its green color and the grains are not entirely hardened. If cut sooner than this, shriveled kernels will

result. If left standing until fully ripe, a bleached appearance, due to the action of the elements, often results and loss from shattering may ensue. Wheat that is fully ripe is also more difficult to handle. Where the area of wheat is large, cutting should begin as early as it can be done safely.

MANNER OF CUTTING.

In practically all of the region under discussion wheat is cut with a self-binder. The header used in the Great Plains area is seldom seen east of Kansas and Nebraska. The old method of cutting with a cradle is still used on very rough land and for small patches where wheat is not an important farm crop.

SHOCKING.

Wheat should be shocked in the field immediately after being cut and bound. A shock is begun by standing two bundles in a nearly upright position with heads together and butts sufficiently apart to prevent falling over. From 8 to 12, and sometimes more, bundles are then set up about these until a round shock of the proper size is formed. The number of bundles to place in a shock depends upon the degree of ripeness, the length of straw, and the size of the bundle, fewer bundles being used where the straw is short or not fully ripe. In placing the bundles, the butts should be jammed into the stubble to insure firmness and the heads should lean inward sufficiently to prevent falling over. When this part of the shock is completed it should be covered as perfectly as possible with two bundles, the heads of which have been broken down at the band, to form a cap. This cap should be placed so as to protect the standing bundles from rain and sun as much as possible. If the heads of the cap are placed on the side of the shock toward the prevailing winds, some protection against blowing off may be afforded.

STACKING.

In the Eastern States wheat is usually stacked outside or stored in mows as soon as it is dried out in the shock, and it is then allowed to remain a few weeks or months until thrashing can be done. Farther west, thrashing directly from the shock is the more common practice. The cost of thrashing from the shock is generally somewhat less than the cost of stacking and thrashing from the stack. Where the stacking is properly done, however, better protection is afforded the grain, which is more important when thrashing can not be done soon after cutting. A "sweating" process also takes place in the stack, which improves to some extent the color, condition, and test weight of the grain and its milling and baking qualities. A similar "sweating" process may apparently take place in shock-thrashed wheat after being placed in the bin. The two chief ad-

vantages of stacking, therefore, are the protection from the weather and the improved quality of the grain, where the farmer does not have sufficient storage space for shock-thrashed grain. The additional cost, if any, resulting from stacking wheat may often be offset by the better price obtainable on account of the better quality resulting from protection and improvement in the stack. It is also possible in wet weather to thrash out the wheat more completely from the straw and to remove more of the chaff when stacking is practiced.

THRASHING.

Thrashing should not be attempted when wheat or straw is wet or tough, as good results can not then be obtained. Wheat can dry out much better in the head than after being thrashed. If thrashed wet and marketed immediately, it is discounted heavily in price; if placed in a bin, it is likely to become hot and badly damaged.

The wheat straw may be stacked in the open, stored in the mow, or spread at once over the field. When the price is good it may be sold. It should never be burned. Straw furnishes excellent roughage for live stock, while by using it for bedding in stalls a large part of the valuable liquid manure can be preserved. Rotted straw from an old straw pile or from straw spread directly on the field makes good manure, as each thousand pounds of straw contains on the average about 8 pounds of potassium, 5 pounds of nitrogen, and smaller amounts of other important plant foods. One thousand pounds of wheat grain removes on the average about 20 pounds of nitrogen and about 3½ pounds each of phosphorus and potassium.

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